

REMARKS

This paper is responsive to the Non-Final Office Action dated April 21, 2004. Claims 1 – 43 were examined. Claims 1 – 43 stand rejected. A non-narrowing amendment has been made to claim 33 to correct grammar. Applicant respectfully traverses all rejections.

Rejections under 35 U.S.C. §103(a)

The Office has rejected claims 1, 2, 4 – 9, 25 – 31, and 36 – 39 under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 4,584,640 granted to MacGregor et al. (MacGregor), in view of U.S. Patent No. 6,128,710 granted to Greenspan et al. (Greenspan), and further in view of U.S. Patent No. 5,081,572 granted to Arnold (Arnold). The Office also rejects claims 10 – 16 and 20 – 24 under 35 U.S.C. §103(a) as being unpatentable over Arnold in view of Greenspan. The Office also rejects claims 33 – 34 and 41 under 35 U.S.C. §103(a) as being unpatentable over MacGregor in view of Greenspan, in view of Mark Allen Weiss's Data Structure and Algorithm Analysis in C++ Second Edition © 1999 (Weiss), and further in view of Arnold. The Office has also rejected claims 32, 35, 40 and 42 under 35 U.S.C. §103(a) as being unpatentable over MacGregor in view of Greenspan, and further in view of Weiss. Applicant respectfully traverses all of these rejections.

As a preliminary matter, Applicant notes that none of the art of record discloses utilization of an atomic multi-target compare and swap operation for accessing a data structure susceptible to concurrent access. The art of record does not address the challenges of accessing a data structure in an environment with competing operations, such as multiple threads attempting to add or delete elements from an array. Applicant's claimed invention provides techniques for implementing a data structure susceptible to concurrent access and managing concurrent accessing of a concurrent shared data structure in a parallel system.

At least one indication that the art of record does not address the challenges of accessing a shared data structure is illustrated in Arnold. Arnold discloses checking whether an array is empty. However, the technique disclosed in Arnold does not confront competing operations or the array being concurrently accessible. Arnold specifically identifies the atomic operations performed when accessing an array. Arnold performs a check for empty state separate from

these atomic operations. The compare and load operation in Arnold is performed subsequent to the check for an empty state (Figs. 4A, 6, and 8). Arnold's technique allows a second thread of control to intervene after checking for an empty state, but before Arnold's compare and load is performed.

Applicant's claims 1, 6, 10, 25, 33 – 34, and 36 recite executing an atomic multi-target compare and swap operation to both access a data structure susceptible to concurrent access and to detect boundary condition states upon failure of the atomic multi-target compare and swap operation. The boundary condition state detection and the accessing of the data structure are constituent aspects of the atomic multi-target compare and swap, thus addressing challenges presented in environments with multiple threads of control. None of the art of record discloses or suggests at least the following limitations:

Claim 1 (similarly recited in claim 6 for a full state)

executing...an atomic dual target compare and swap operation (DCAS)
to update...and returning from the DCAS, on failure thereof,
an indication by which an empty state of the array is
detectable

Claim 10

the second multi-way compare and swap performing the access and,
on failure thereof, returning an indication disambiguating
a retry state and the boundary condition state of the
double-ended data structure

Claim 25

if successful completion of one of the first and the second
competing access operations results in a boundary condition
state of the array, the DCAS of the other of the first and
the second access operations fails and returns an
indication thereof

Claim 33 (similarly recited in claim 34 for empty state)

on failure, the DCAS returns an indication by which a full state
of the contiguous array is detected

Claim 36

the push operation employs a first instance of an atomic dual target compare and swap (DCAS) operation to update one of the opposing indices and a corresponding element of the contiguous array while returning on failure, an indication by which a full state of the contiguous array is detected.

Integrating access and boundary condition state detection for managing concurrent access to a data structure is similarly recited in independent claims 15 and 23. Again, none of the art of record discloses or suggests incorporating detecting boundary condition states with access of a data structure in an atomic multi-target compare and swap operation. More specifically, none of the art of record discloses or suggests “execution of an atomic dual target compare and swap (DCAS) to interrogate instantaneous values of a first end index and a dequeue element adjacent to that identified thereby for a signature indicative of an empty state of the array” as recited in claim 15 and similarly in claim 23 (full state).

Claim 25 and 26 – 31 further emphasize the utilization of Applicant’s invention in a parallel system with recitation of competing operations utilizing the atomic multi-target compare and swap operation for accessing an array and receiving indication of boundary condition states for the array.

With regard to claim 32, the Office Action never identifies art that discloses or suggests “a contiguous array S...a left index L and a right index R into the contiguous array...wherein at least the S[L] and S[R] entries encode a distinguishing value” as recited in claim 32.

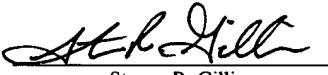
With regard to claim 40, as previously stated, the art of record does not disclose or suggest “at least one functional sequence implementing an access operation on a concurrent shared object...instances of the at least one functional sequence concurrently executable by plural processors of a multiprocessor.” The art of record discloses operations for singly linked lists and doubly linked lists, but does not evince techniques for accessing a concurrent shared object. The absence of a disclosure or suggestion related to a concurrent shared object is reinforced with the separation of atomic operations and checking of the boundary condition state in Arnold as previously discussed above.

With regard to claim 43, none of the art of record discloses or suggests “at least one atomic dual target compare and swap (DCAS) operation to disambiguate a retry state and a boundary condition state of the array” as recited in claim 43. Again, the art of record does not disclose or suggest utilizing a DCAS to determine whether a DCAS failed because of the boundary condition state of the array. The art of record determines the state of the array separate from access operations, and does not address “coordinating competing access operations.”

None of the art of record discloses or suggests Applicant’s claims, and especially does not disclose or suggest Applicant’s independent claims. For at least the reasons given above, all of Applicant’s claims are allowable over the art of record. Furthermore, Applicant’s dependent claims are at least allowable for the reasons above and because they depend from corresponding ones of the above allowable independent claims.

Conclusion

In summary, claims 1 – 41 are in the case. All claims are believed to be allowable over the art of record, and a Notice of Allowance to that effect is respectfully solicited. Nonetheless, if any issues remain that could be more efficiently handled by telephone, the Examiner is requested to call the undersigned at the number listed below.

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 Steven R. Gilliam	<u>Aug -23-2004</u> Date

Respectfully submitted,



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